Performance and resilience to liquidity disruptions in interdependent RTGS payment systems

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Motivation

• The 2001 Group of Ten “Report on Consolidation in the Financial Sector” (the Ferguson report) noted a possible increased interdependence between the different systems due to:
  – The emergence of global institutions that participate to many systems
  – The emergence of global service providers offering services to many systems
  – The development of DvP procedures linking RTGS and SSS
  – The development of CLS

• The report suggested that these trends might accentuate the role of payment and settlement systems in the transmission of disruptions across the financial system.

• To complement this previous work, the CPSS (Committee on Payment and Settlement Systems) commissioned a working group to:
  – describe the different interdependencies existing among the payment and settlement systems of CPSS countries
  – analyze the risk implications of the different interdependencies
Motivation

- Could a modeling approach provide any useful additional information to the regulators?
- So far, payment and settlement system modeling has been mainly limited to a single system, with a few exceptions
- We want to model the interactions between two payment systems and understand how interdependencies arise
- We wish to understand how disruptions in one system manifest in the other
Coupled RTGS model

Model description

- Two RTGS systems in two different currencies: $ and €
- Both systems are similar in structure with 100 banks
- Six “global banks”. Top three banks in each system have a presence also in the other system
- The global banks make FX trades (at constant exchange rate) among each other
- All banks make local payments
• Payment instructions arrive according to a non-homogenous Poisson process
  – intuition: customers who have received funds issue payments more frequently than bank customers who have already sent many payments

• FX trades arrival is similar as above, now taking into account balances in both currencies
  – E.g. banks with high euro positions are likely to sell euro and vice versa

• Those two systems are linked
  – Via the dual participation of some global banks that can make FX trades (institution-based interdependency)
  – Via a possible PvP (Payment versus Payment) constraint on the FX trades (system-based interdependency), the alternative being a non-PvP settlement
Correlation dynamics

High liquidity
PvP or non-PvP

Correlation: 0.22
(institution-based interdependency)

Low liquidity
non-PvP

Correlation: -0.02
(none)

Low liquidity
PvP

Correlation: 0.83
(system-based interdependency)
Summary of main results

- **PvP**
  - increases queues
  - eliminates exposures

- **Lower liquidity**
  - increases queues
  - Increases exposures (in case of non-PvP)

- **Liquidity differences in the two systems**
  - Reducing liquidity in one system increases queuing in the other (in case of PvP)
  - Banks selling the more liquid currency face higher exposures (in case of non-PvP)

- **Higher priority for FX trades**
  - Decreases queues in the more liquid system (in case of PvP)
  - Does not affect queues when both systems have same liquidity
  - Substantially reduces exposures (in case of non-PvP)
Operational disruption

• An operational disruption affects a significant local € bank
  – The affected bank does not participate in RTGS $, nor engage in FX transactions
  – The affected bank is unable to submit its € local payments for a certain duration
  – The affected bank acts as a liquidity sink for RTGS €

• To which extent will the disruption affect RTGS $?
  – Four different cases:
    • PvP or non-PvP
    • High Liquidity or Low Liquidity (the same in both systems)

• What are the channels of propagation through which the crisis spreads from one RTGS to the other?
Operational disruption

PvP, High Liquidity

PvP High Liquidity
Operational disruption

PvP High Liquidity
• Outage: settlement rate in RTGS $ decreases (-50 %)
Operational disruption

PvP High Liquidity
- Outage: settlement rate in RTGS $ decreases (-50 %)
- Recovery: settlement rate in RTGS $ overshoots
Operational disruption

Period A
- Steady state

PvP High Liquidity
- Outage: settlement rate in RTGS $ decreases (-50 %)
- Recovery: settlement rate in RTGS $ overshoots
Operational disruption

**Period A**
- Steady state

**Period B**
- € balances vanish
- € local payments are queued
- Both legs of FX trades are queued, RTGS $ deprived of FX activity

**PvP High Liquidity**
- Outage: settlement rate in RTGS $ decreases (-50 %)
- Recovery: settlement rate in RTGS $ overshoots
Operational disruption

Period A
- Steady state

Period B
- € balances vanish
- € local payments are queued
- Both legs of FX trades are queued, RTGS $ deprived of FX activity

Period C
- RTGS $ down to local activity

PvP High Liquidity
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Operational disruption

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- Steady state

**Period B**
- € balances vanish
- € local payments are queued
- Both legs of FX trades are queued, RTGS $ deprived of FX activity

**Period C**
- RTGS $ down to local activity

**Period D**
- Because of the queuing of FX trades (PvP), customers have lower $ funds and make fewer $ local payments

**Period E-F**
- Queued € local payments settle
- Queued FX trades settle

**Period G**
- Return to equilibrium generates extra trades

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Operational disruption

PvP Low Liquidity
Operational disruption

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PvP Low Liquidity

• Outage: settlement rate in RTGS $ decreases (-65 %)
• Recovery: settlement rate in RTGS $ overshoots (reaches maximum rate)
Operational disruption

Period B
- € balances vanish
- € local payments are queued
- Both legs of FX trades are queued, RTGS $ deprived of FX activity

Period C
- The queuing of FX trades decreases $ deposits. Agents are uncertain about their $ position, fewer $ local payments emitted
- The distribution of $ deposits is brought out of equilibrium because of the disruption. In this low liquidity context, this causes $ local payments to be queued

Period D
- Queued € local payments settle
- Queued FX trades settle
- Queued $ local payments settle

Period E
- Return to equilibrium marginally affects settlement rate

PvP Low Liquidity
- Outage: settlement rate in RTGS $ decreases (-65 %)
- Recovery: settlement rate in RTGS $ overshoots (reaches maximum rate)
Operational disruption

Non-PvP, High Liquidity
Non-PvP High Liquidity

- Outage: settlement rate in RTGS $ decreases (-17 %)
- Recovery: no overshoot in RTGS $
Operational disruption

Non-PvP High Liquidity

• Outage: settlement rate in RTGS $ decreases (-17 %)
• Recovery: no overshoot in RTGS $
Operational disruption

Period B
- € balances vanish
- € local payments are queued
- € leg of FX trades are queued
- $ leg of FX trades still settle

Period C
- The queuing of € local payments decreases € deposits. Agents are uncertain about their € position, fewer FX trades emitted. RTGS $ is deprived from FX activity

Period D
- Only local activity in RTGS $

Period E
- Queued € local payments settle
- Queued € leg of FX trades settle

Period F
- Return to equilibrium generates extra trades

Non-PvP High Liquidity
- Outage: settlement rate in RTGS $ decreases (-17 %)
- Recovery: no overshoot in RTGS $
Operational disruption

Non-PvP Low Liquidity

Simulation Time

Settlement Rate (Payments/Time)

Dollar System
Euro System

non-PvP, Low Liquidity
Operational disruption

Non-PvP Low Liquidity
• Outage: settlement rate in RTGS $ decreases (-25 %)
Operational disruption

Non-PvP Low Liquidity

- Outage: settlement rate in RTGS $ decreases (-25 %)
- Recovery: settlement rate in RTGS $ overshoots
Operational disruption

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• € balances vanish
• € local payments are queued
• € leg of FX trades are queued
$ leg of FX trades still settle

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• The queuing of € local payments decreases € deposits. Agents are uncertain about their € position, fewer FX trades emitted. RTGS $ is deprived from FX activity

Period D
• Only local activity in RTGS $  
• The distribution of $ deposits is brought out of equilibrium because of the disruption. In this low liquidity context, this causes $ local payments to be queued

Period E
• Queued € local payments settle
• Queued FX trades settle
• Queued $ local payments settle

Non-PvP Low Liquidity
• Outage: settlement rate in RTGS $ decreases (-25 %)
• Recovery: settlement rate in RTGS $ overshoots
Operational disruption

Non-PvP High Liquidity, FX exposures
Non-PvP High Liquidity, FX exposures

- Outage: huge increase in € owed (1 000 times normal exposures)
Operational disruption

Non-PvP High Liquidity, FX exposures

- Outage: huge increase in € owed (1 000 times normal exposures)
- Recovery: large increase in $ owed (15 time normal exposure)
Cross-currency channels of disruption propagation

- Channel 1: Low € balances at the CB prevent settlement of € leg of FX transactions (PvP) or create FX exposures (non-PVP)
Cross-currency channels of disruption propagation

- **Channel 1:** Low € balances at the CB prevent settlement of € leg of FX transactions (PvP) or create FX exposures (non-PVP)

- **PvP:**
  - All FX settlement activity stops, RTGS $ is deprived from FX settlement activity
Cross-currency channels of disruption propagation

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  - All FX settlement activity stops, RTGS $ is deprived from FX settlement activity
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- **Non-PvP:**
  - Very high exposures (unsettled € legs) during crisis
Cross-currency channels of disruption propagation

• **Channel 2: Low € customer funds lead to fewer emitted FX trades**
  – Banks customers’ € liquidity is trapped within queued payments. Therefore, customers emit fewer FX trades
Cross-currency channels of disruption propagation

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  - Banks customers’ € liquidity is trapped within queued payments. Therefore, customers emit fewer FX trades

This leads to RTGS $ being eventually deprived of FX activity, even in the non-PvP case
Cross-currency channels of disruption propagation

- **Channel 3: As not all banks are similarly affected, the system becomes unbalanced**
  - The FX banks for which the disrupted bank is an important counterparty see their level of € customer funds decrease more rapidly.
  - These banks become net € buyers ($ sellers) on the FX market. RTGS $ becomes unbalanced.
Cross-currency channels of disruption propagation

• **Channel 3: As not all banks are similarly affected, the system becomes unbalanced**
  – The FX banks for which the disrupted bank is an important counterparty see their level of € customer funds decrease more rapidly.
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• **Low Liquidity:**
  – this leads to the queuing of several $ local payments, even in the non-PvP case…
Cross-currency channels of disruption propagation

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- **Low Liquidity**:
  - this leads to the queuing of several $ local payments, even in the non-PvP case…
  - And to an overshoot at recovery, even in non-PvP case
Cross-currency channels of disruption propagation

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• **Low Liquidity:**
  – this leads to the queuing of several $ local payments...
  – And to an overshoot at recovery, even in non-PvP case

• **Non-PvP:**
  – This creates a peak in $ owed exposures at recovery, event at high liquidity
Conclusions

- A simple model of interconnected RTGS was developed
- During normal operation, the two RTGS are shown to be interdependent
- When a liquidity crisis affects one RTGS, the crisis propagates to second RTGS in all considered cases
  - PvP:
    - sharp decrease in activity (local and FX) in second RTGS
  - Non-PvP:
    - Decrease in activity in second RTGS due to fewer FX trades emitted
    - At low liquidity, local payments in second RTGS are also affected
    - Large increase of FX exposures during crisis and recovery